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AI/ML Atmospheric Parameters Retrieval Using the "Atmospheric Retrievals conditional Generative Adversarial Network (ARcGAN)"

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Abstract : Exoplanet atmospheric parameters retrieval is a complex, computationally intensive, inverse modeling problem in which an exoplanet's atmospheric composition is extracted from an observed spectrum. Traditional Bayesian sampling methods require extensive time and computation, involving algorithms that compare large numbers of known atmospheric models to the input spectral data. Runtimes are directly proportional to the number of parameters under consideration. These increased power and runtime requirements are difficult to accommodate in space missions where model size, speed, and power consumption are of particular importance. The use of traditional Bayesian sampling methods, therefore, compromise model complexity or sampling accuracy. The Atmospheric Retrievals conditional Generative Adversarial Network (ARcGAN) is a deep convolutional generative adversarial network that improves on the previous model's speed and accuracy. We demonstrate the efficacy of artificial intelligence to quickly and reliably predict atmospheric parameters and present it as a viable alternative to slow and computationally heavy Bayesian methods. In addition to its broad applicability across instruments and planetary types, ARcGAN has been designed to function on low power application-specific integrated circuits. The application of edge computing to atmospheric retrievals allows for real or near-real-time quantification of atmospheric constituents at the instrument level. Additionally, edge computing provides both high-performance and power-efficient computing for AI applications, both of which are critical for space missions. With the edge computing chip implementation, ArcGAN serves as a strong basis for the development of a similar machine-learning algorithm to reduce the downlinked data volume from the Compact Ultraviolet to Visible Imaging Spectrometer (CUVIS) onboard the DAVINCI mission to Venus.

Keywords : deep learning, generative adversarial network, edge computing, atmospheric parameters retrieval
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